62-1540

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V. I. Arabadzhi and K. I. Rudik

UNEDITED ROUGH DRAFT TRANSLATION

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English Pages: 6

Source: Izvestiya vysshikh uchebnykh zavedeniy. Fizika, No. 1, 1962, pp. 103-104

SC-1579
SOV/139-62-0-1-16/32

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KLYDONOGRAMS OF INTERACTING ELECTRODES

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As is known, klydonograms, sometimes called Lichtenberg figures, arise from the light emitted during a discharge [1]. They may assume different forms, depending on the nature of the surrounding gas. In spite of the fact that klydonograms are formed as a result of the development of surface discharges, they are still of use in judging the general nature of the development of streamers in the gaseous medium, since the basic patterns of discharge processes are not substantially altered in this case.

We carried out a number of experiments for the purpose of ascertaining the change in the nature of klydonograms of interacting electrodes at different pressures of the gaseous medium (air). The klydonograms were obtained by us on both black-and-white and colored photographic materials of normal sensitivity. The feeding of the voltage to the electrodes could be accomplished either by means of a spring circuit-breaker (in this case the exposure time of the electrodes under voltage was 10^{-3} sec), or by closing the contacts of the voltage-feeding circuit with the aid of a bullet shot out of a small-caliber gun (in this case the electrodes were kept under voltage for 10^{-6} sec).

However, after a number of tests the first method of feeding the voltage was found to be more suitable for our purposes. The electrodes in the form of brass spikes were placed in contact with the film on the side closer to the photoemulsion and perpendicular to the latter. We were able to feed to the electrodes voltages ranging from 5 to 15 kw, but the voltages most suitable for our purposes were found to be average voltages in this range. The accompanying photographs (Fig. 1) show the development of a discharge between two corona electrodes, to each of which a positive or negative voltage of 9 kw was fed. The distance between the electrodes remained invariable (35 mm) in every series of experiments, while the pressure varied from normal to 30 mm Hg. The evacuation of the vacuum cap under which the electrodes were located was accomplished with the aid of a Komovskiy pump. The film to be exposed during the experiment was placed on a dielectric.

As a result of an analysis of the photographs in Fig. 1 we arrive at the conclusion that with a reduction in pressure the channels through which the streamers propagate thicken noticeably and unbend. As the discharge develops, streamers, which close the discharge gap, appear in the gap between the electrodes. With a decrease in the air pressure more and more of these streamers appear. While at normal pressure a corona develops more easily on the positive electrode, with a decrease in pressure, as can be seen from Fig. 1c, the conditions of the development of a corona at electrodes of different polarity are equalized and then become somewhat more favorable at the negative electrode. This is due to the fact that the streamer channels at the negative electrode are worn through by an electron volume charge, while the scales of energy consumption of the electrical field upon a decrease in pressure will increase more rapidly in the case of electrons than in the case of positive ions. At air pressures below 50 mm Hg the discharge picture assumes the form of a thickened, diffusely liminous column elongated along the line joining the electrodes (Fig. 1d).

On colored photographic materials the discharge picture at reduced pressures appears more blurred, since a considerable part of the radiation transmitted from layer to layer of the three-layered emulsion absorbed and scattered. In our work we used color film intended for filming under conditions of daylight illumination. Therefore under our experimental conditions, where the exposure of the photographic materials took place in the dark, this film served only as a colored discharge indicator.

We also studied klydonograms obtained by subjecting a photoemulsion to the action of a charge distributed in a volume occupied by a powder. For this purpose, we used sulfur and iron powders, which were poured onto the photoemulsion in the form of conical mounds. The distance between the inner edges of these mounds could vary from 1.5 to 2 cm. The electrodes of an electrostatic machine were introduced into these powders from above (to approximately half the depth of the mound), after which the photoemulsion was subjected at normal pressure to the action of an electrical field for a period of time of the order of 10^{-3} sec. As in the preceding experiments, the distance between the electrodes feeding the voltage to the film was 3.5 cm, and the film was placed on a dielectric during exposure. In the case of sulfur a large red spot formed on the color film at the positive electrode, while in the case of iron a grayish-blue spot formed. The formation of different colored figures at the electrodes is apparently caused by differences in the fields which force their way through the sulfur and iron powders to the photoemulsion. The corona picture at the negative electrode at normal air pressure is, on the whole, less distinct; in the case of sulfur powder under our experimental conditions it was, for all practical purposes, not recorded. The picture of the development of a corona in a powder at the positive electrode is shown on black-and-white film in Figs. 2a and 2b for sulfur and iron, respectively. The fixation of a discharge through powder is of great significance for understanding the conditions of a discharge between regions of concentration of a volume charge (e.g., for understanding the development of lightning).

Thus we arrive at the conclusion that with a decrease in the air pressure the streamer channels unbend and thicken, while the conditions of development of a discharge at electrodes of different polarities, judging by the picture on the photoemulsion, are at first equalized and then become somewhat more favorable at the negative electrode. At pressures below 50 mm Hg klydonograms of interacting electrodes assume the form of thickened luminous columns elongated along the line joining the electrodes. The klydonograms obtained at reduced pressures on color film are more blurred. Original color phenomena occur on klydonograms in the case of a discharge on film through powder. The results described are useful for understanding the development of small-scale electrical discharges.

Fig. 1a. Normal pressure.

Fig. 1b. Pressure 240 mm Hg.

Fig. 1c. Pressure 210 mm Hg.

Fig. 1d. Pressure 30 mm Hg.

Fig. 1. Klydonograms on black-and-white film. In every case the distance between the electrodes was 35 mm, the discharge time was 10^{-3} sec, and the voltage on the electrode was $\pm$ 9 kw.

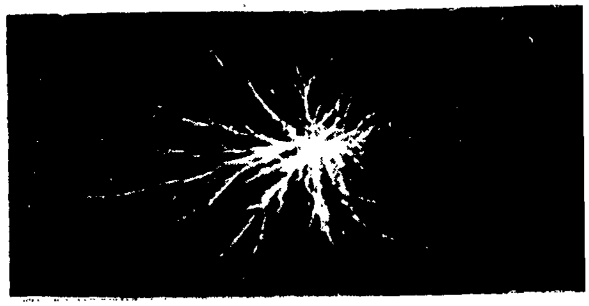

Fig. 2a.

Fig. 2b.

Fig. 2. Picture of a discharge at the positive electrode on black-and-white film through sulfur (a) and iron (b) powders. Voltage on electrodes (9 kw).

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The A. M. Gor'kiy Pedagogical Institute, Minsk

Received on January 2, 1961

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